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The Use of "Buildup Ratios" as Indicators of Mountain Pine Beetle Population Trends

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INTRODUCTION

Forest managers and entomologists of the Intermountain Region rely on various techniques for monitoring and predicting mountain pine beetle (Dendroctonus ponderosae Hopk.) populations in lodgepole pine. One technique that has been used is that of counting both new and old attacks and presenting these numbers as a proportion of the trees killed by the beetle during a two-year period. This proportion is usually referred to as a "buildup ratio" or "attack ratio." Because they are useful in predicting the potential number of trees killed the following year, buildup ratios can be considered in control decisions.

OBJECTIVES

The primary objective of this report is to describe a method of collecting necessary field data and the use of these data in predicting expected beetle-caused lodgepole pine mortality one year in advance by applying buildup ratios. The concepts are not meant to conflict with any existing evaluation or presuppression survey methods but rather are designed to supplement them. They will bring us one step further in our attempt to understand one phase of mountain pine beetle population dynamics.

A secondary but nonetheless vital objective is to illustrate the high level of tree mortality that can result if certain ratios are sustained for very many years.

SURVEY METHODS

Buildup ratios cited in past reports and control proposals have been derived in numerous ways. The intent here is to propose a generally acceptable technique for collecting the necessary field data. The concepts can be integrated into present survey procedures rather easily.

HOW TO USE THE BUILDUP RATIO

The predicted potential number of attacked trees (those which are expected to be attacked by the present broods) is dependent upon the buildup ratio and the number of currently attacked trees. The cumulative number of dead trees next year will be the total number of trees killed to date added to the product of the trees attacked this year multiplied by the buildup ratio.

To simplify,

assume y = the cumulative number of trees killed through this year,

y' = the potential cumulative number of killed trees predicted through next year,

x = the number of trees killed this year,

x_1 = the number of trees killed last year,

and $b = \frac{x}{x_1}$

The equation $y' = y + \frac{x}{x_1}(x)$ results.

Reduced, the equation becomes:

$$y' = y + bx$$

The following hypothetical example shows how the formula can be used. A calculation format such as this is recommended. In this case, only lodgepole pine 8" d.b.h. and over are considered.

Years	No. of Trees/Acre Killed this Year (x)	Cumulative No. of Trees/Acre Killed (y & y')	Remaining Lodgepole Pine Stocking/Acre	Buildup Ratio
1964	0	0	150	
1965	2	2	148	No Ratio
1966	3	5	145	1.5:1
1967	3	8	142	1:1
1968	(3)	(11)	(139)	1:1

In 1964 no beetle-caused tree mortality occurred. In 1965 two trees per acre were attacked and killed. Three additional trees were killed in 1966 and again in 1967. The last recorded ratio is 1:1. To estimate the potential amount of tree mortality in 1968, the last recorded ratio is multiplied by the number of trees killed in 1967.*

* History of the outbreak may show that the most current ratio does not appear as indicative of the recent trend as some other. In such cases, the most appropriate ratio should be applied to the x value.

$y' = y + bx$

$= 8 + 1\ (3)$

$= 8 + 3$ (Three additional killed trees projected for 1968)

$y' = 11$ (Total projected cumulative total for 1968)

Not only can a projected cumulative total of killed trees and a projected number of new kills in 1968 be derived but one can also reduce the average stocking figure by 11 for a projected 1968 residual stocking of 139. The latter figure should be of interest to the forest manager who may have arbitrarily established an average minimum lodgepole pine stocking threshold.

In the above example, per acre counts were used. The forest manager does need some unit to work with and as his basic stocking is measured by the acre, it is wise to equate the data on this basis.

THE RELATIVE EFFECTS OF VARIOUS BUILDUP RATIOS

The following graph illustrates how different ratios affect the projected cumulative totals of killed trees. The graph is dimensionless regarding area, however, and total cruise counts apply equally as well as per acre counts. The number of trees killed the first year has been arbitrarily set as two. For comparative purposes, this x value has been expanded by each of eight ratios.

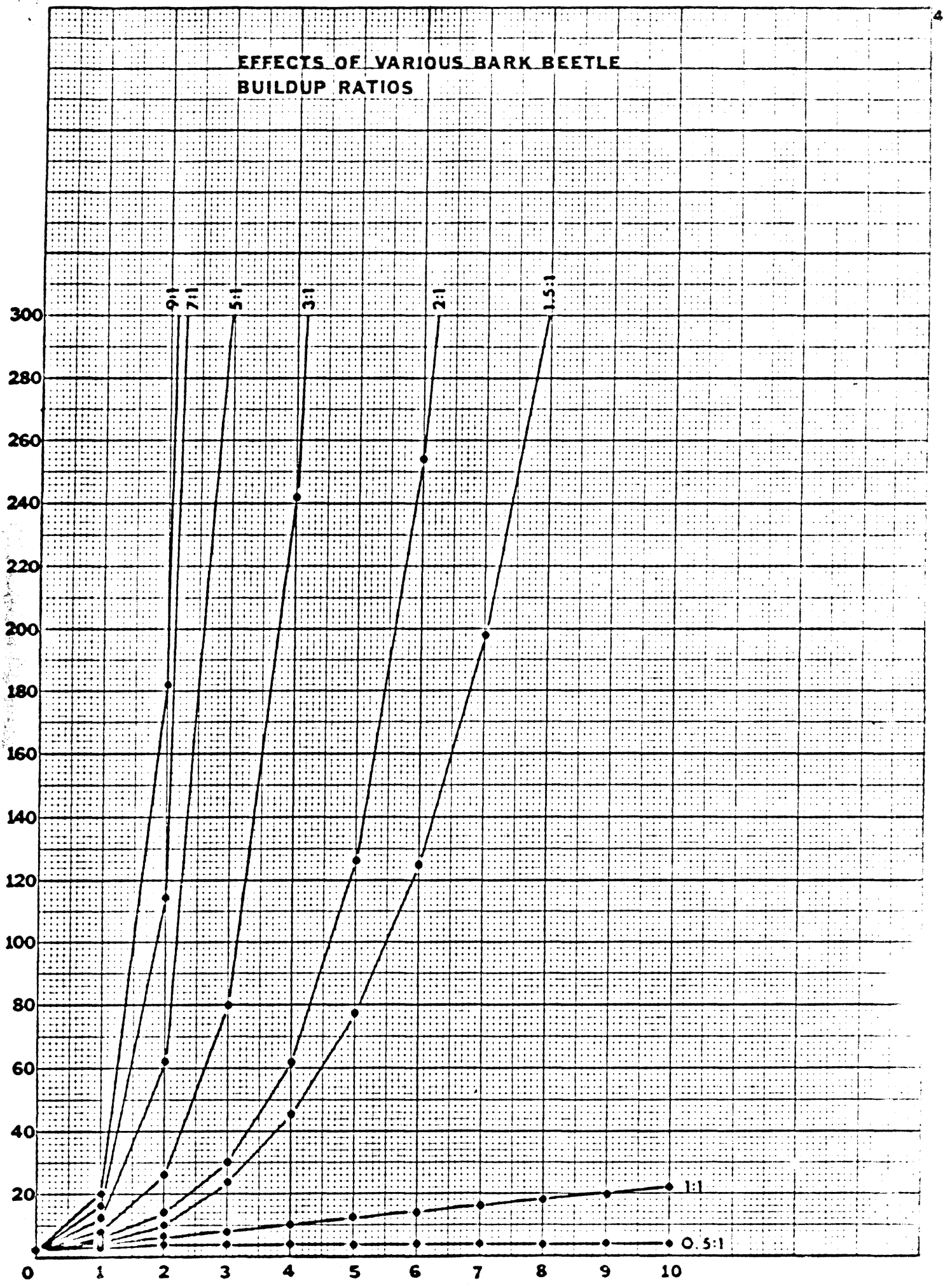
It can be seen from the graph that a 1:1 ratio results in a continuing depletion of timber but this cumulative mortality continues at a constant rate. The resulting trend line is thus a linear relationship. The "trend" is static, but the cumulative total must increase.

In the case of 0.5:1, there is a situation where the trend declines. Inasmuch as b is less than 1.0, we will be multiplying it by an increasingly lower x each year this ratio prevails. Therefore, the projected number of killed trees becomes infinitesimal after a relatively few years, and in actuality we would experience a dropoff in the beetle population to a very endemic status.

Ratios of more than 1:1 are mathematical progressions which increase at ever increasing rates. A high ratio or even several high ratios alternating from year to year cannot be sustained for very many years, especially, if there is already a fairly high cumulative number of trees killed (y). For example, a ratio of 2:1 sustained for five consecutive years will result in 126 trees killed.

FIELD COLLECTION OF THE DATA

The present cumulative number of killed trees (y), the number of trees killed during the current year (x), and the number of trees killed last



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year (x_1) can all be tallied during one survey by strip, fixed plot, or variable plot cruising. The important thing is that a sufficient and representative portion of the infestation is traversed and sampled.

CONFIDENCE LIMITS OF THE ESTIMATE

Inasmuch as the buildup ratio represents only the area sampled, it is obvious that some "confidence limits" of the estimated totals will result unless the entire infestation is cruised (this is seldom practical or feasible). The goal, then, must be to hold confidence limits to a minimum by making the length of cruise lines or the number of sample plots adequate. We should then recognize the inherent limitations of our buildup ratios or tree-count "estimates."

For example, if our estimates for two successive years have confidence limits or a "plus or minus" factor of as much as 20%, then the data that we might collect from resurveys along different lines or from different plots may vary as follows:

BUILDUP RATIOS

LAST YEAR	THIS YEAR
150 new hits ± 20% : 75 old hits ± 20%	150 new hits ± 20% : 150 old hits ± 20%
or 150 ± 30 : 75 ± 15	150 ± 30 : 150 ± 30
or 120 to 180 : 60 to 90	120 to 180 : 120 to 180
Can result in buildup ratios of —	
120 : 90 = 1.3:1	120 : 180 = 0.7:1
or 180 : 60 = 3.0:1	180 : 120 = 1.5:1

In the above example, one can see how the basic data and the resultant population trends might vary if resurveys were made assuming 20% confidence limits. The point is that our cruise data must be representative and complete enough to prevent such misrepresentations.

On the subject of sampling accuracy, it is well to consider just how far off the real tree counts one might be. Actually, the more attacked trees we tally (either old or new) the better the estimate. Let's take from a 1-mile cruise line a ratio of 200 new hits to 100 old hits. This reduces to 2:1. In order to arrive at a greatly different ratio, we would have to encounter a large number of new or old hits. To reverse the ratio, for instance, would require an additional 300 old hits and no new hits, giving a ratio of 200:400 or 1:2. The likelihood of this occurring very soon is small.

It is in very low-density outbreaks that we encounter potential errors. For example, if on the same 1-mile line we encounter only four new hits and two old hits for a ratio of 2:1, it is very probable that in just a few more chains of cruise line we might pick up just three more old hits, making the ratio 2:4 or 1:2!

AREA REPRESENTED

Our buildup ratio represents a unit area of infestation. It is important to realize that the ultimate ratio we arrive at is merely an estimate of the entire area or the "average" acre within the infestation. A 2:1 ratio may approach the actual tally if the infestation was 100% cruised although no single acre in the stand may actually have two new hits for every one hit last year. Consequently, we expect to have groups in the infestation sustaining many hits and other groups of green healthy trees. This distribution is well known.

CONCLUSIONS AND SUMMARY

Several aspects of population buildup ratios have been reviewed. A formula and a calculation format are provided for estimating potential tree mortality the next year. A graph illustrates the mathematical potential of applying ratios to numbers of currently attacked trees. One very striking point is that unrealistically high buildup ratios cited year after year can result in stand depletion figures that actually exceed the original stocking levels. It also becomes apparent that in order for buildup ratios to be meaningful, the current cumulative number of killed trees and the number of currently killed trees should be cited. The buildup ratio cannot, of course, account for any unforeseen natural mortality factors within the insect population. The ratio shows the mathematical potential of the situation and must be considered along with whatever forces may be acting on the population such as weather, predation, parasitism, gross declines in physiological vigor, host tree susceptibility, and other influences. It is hoped that this review will bring the usefulness of buildup ratios into better perspective.

Bruce H. Baker
Entomologist
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